The Periodic Table

A Brief History of the Periodic Table
and other important stuff

In the Beginning

- prerequisite to the construction of the periodic table was the discovery of the individual elements
- the next 200 years, chemists acquired a vast body of knowledge concerning the properties of elements
- By 1869, a total of 63 elements had been discovered

Law of Triads

- In 1817 **Johann Döbereiner**, after discovering the halogen triad composed of chlorine, bromine, and iodine and the alkali metal triad of lithium, sodium and potassium he **proposed that nature contained triads of elements the middle element had properties that were an average of the other two members when ordered by the atomic weight (the Law of Triads**).

First Attempts At Designing a Periodic Table

- If a periodic table is regarded as an ordering of the chemical elements demonstrating the periodicity of chemical and physical properties
- credit for the first periodic table (1862) probably should be given to A.E.Beguyer de Chancourtois.

First Attempts At Designing a Periodic Table

- de Chancourtois transcribed a list of the elements positioned on a cylinder in terms of increasing atomic weight.
- When the cylinder was constructed so that 16 mass units could be written on the cylinder per turn, closely related elements were lined up vertically.
- This led de Chancourtois to propose that "the properties of the elements are the properties of numbers."

Law of Octaves

- in 1863 John Newlands classified the 56 established elements into 11 groups based on similar physical properties,
- noting that many pairs of similar elements existed which differed by some multiple of eight in atomic weight.

Law of Octaves

- Law of Octaves stated that any given element will exhibit analogous behavior to the eighth element following it in the table.

Who Is The Father of the Periodic Table?

- There has been some disagreement about who deserves credit
- the German Lothar Meyer or the Russian Dmitri Mendeleev
- Both chemists produced remarkably similar results at the same time working independently of one another.

Who Is The Father of the Periodic Table?

- Meyer's 1864 textbook included a rather abbreviated version of a periodic table
- In 1869, Dmitri Mendeleev organized his material in terms of the families of the known elements which displayed similar properties

Who Is The Father of the Periodic Table?

- He observed similarities between the series Cl-K-Ca , Br-/Rb-Sr and I-Cs-Ba.
- In an effort to extend this pattern to other elements, he created a card for each of the 63 known elements.
- Each card contained the element's symbol, atomic weight and its characteristic chemical and physical properties.

Who Is The Father of the Periodic Table?

- From this table, Mendeleev developed his statement of the periodic law and published his work
- The advantage of Mendeleev's table over previous attempts was that it exhibited similarities not only in small units such as the triads, but showed similarities in an entire network of vertical, horizontal, and diagonal relationships.

Who Is The Father of the Periodic Table?

- However, even after redetermining atomic weights, some elements still needed to be placed out of order of their atomic weights.
- From the gaps present in his table, Mendeleev predicted the existence and properties of unknown elements, which he called eka-aluminum, eka-boron, and eka-silicon.
- The elements gallium, scandium and germanium were found later to fit his predictions quite well.

Who Is The Father of the Periodic Table?

- Even if Mendeleev's table was published before Meyers', his work was more extensive predicting new or missing elements.
- In all Mendeleev predicted the existence of 10 new elements, of which seven were eventually discovered -- the other three, atomic weights 45, 146 and 175 do not exist.

Discovery of the Noble Gases

- In 1895, the discovery of a new gaseous element named argon, which proved to be chemically inert. and did not fit any of the known periodic groups.
- In 1898, argon placed into the periodic table between chlorine and potassium in a family with helium

Atomic Structure and the Periodic Table

- it remained for the discoveries of scientists of the 20th Century to explain why the properties of the elements recur periodically.
- With the discovery of isotopes of the elements, it became apparent that atomic weight was not the significant player in the periodic law as Mendeleev, Meyers and others had proposed.

Atomic Structure and the Periodic Table

- It has become quite clear that the properties of the elements varied periodically with atomic number.
- The question of why the periodic law exists was answered as scientists developed an understanding of the electronic structure of the elements

The Modern Periodic Table

- The last major changes to the periodic table resulted from Glenn Seaborg's work in the middle of the 20th Century
- Starting with his discovery of plutonium in 1940, he discovered all the transuranic elements from 94 to 102.
- He reconfigured the periodic table by placing the actinide series below the lanthanide series.

The Modern Periodic Table

- In 1951, Seaborg was awarded the Nobel Prize in chemistry for his work. Element 106 has been named seaborgium (Sg) in his honor.

Parts of the Periodic Table

- Rows on the Periodic Table are called periods or series.
  - They are number 1 to 7. These numbers correspond to the number of principle energy levels the atom has in the ground state

Parts of the Periodic Table

- The columns on the Periodic Table are called groups or families of elements
  - The elements are grouped according to the physical and chemical properties.
  - The columns a numbered 1 to 18
  - The old system used Roman numerals and letters to denote groups and subgroups

Element Families on the Periodic Table

- The 112 elements can be divided, by their properties, into 9 separate families (groups).
- These groups are Alkali Metals, Alkaline Earth Metals, Transition Metals, Rare Earth Elements, Other Metals, Metalloids, Non-Metals and Halogens.

Alkali Metals

- found in Group 1 of the periodic table (formerly known as group IA),
- are very reactive metals that do not occur freely in nature.
- These metals have only one electron in their outer shell.
- Therefore, they are ready to lose that one electron in ionic bonding with other elements.

Alkali Metals

- The alkali metals are lithium, sodium, potassium, rubidium, cesium, and francium.
- Cesium and francium are the most reactive group.
- The oxidation number for these metals is always +1.

Alkaline Earth Elements

- The alkaline earth elements are metallic elements found in the second group.
- The alkaline earth elements are: beryllium, magnesium, calcium, strontium, barium, and radium.
- All alkaline earth elements have 2 electrons to give away and an oxidation number of +2, which makes them very reactive.

Transition Metals

- 38 elements in groups 3 through 12 of the periodic table are called "transition metals".
- Has the properties of metals
- The interesting thing about transition metals is that their valence electrons are present in more than one shell.
- three noteworthy elements in this family are iron, cobalt, and nickel; these are the only elements known to produce a magnetic field.
- The oxidation numbers vary but are always positive.

Other Metals

- 7 elements classified as "other metals" are located in Groups 13, 14, and 15.
- they are not the same as the transition elements. These elements, unlike the transition elements, do not exhibit variable oxidation states, and their valence electrons are only present in their outer shell.
- They have oxidation numbers of+3, ± 4, and -3.

Non-Metals

- Non-metals are the elements in groups 14-16
- They have oxidation numbers of: ±4, -3, and -2,

Rare Earth Elements

- The thirty rare earth elements are composed of the lanthanide and actinide series.
- One element of the lanthanide series and most of the elements in the actinide series are called trans-uranium, which means synthetic or man-made.

Rare Earth Elements

- All of the rare earth metals are found in Group 3 of the periodic table, and the 6th and 7th periods.
- All rare earth elements have 3 electrons in their outer shells.
- They have varying oxidation numbers that are always positive.

Metalloids

- Metalloids are the elements found along the stair-step line that distinguishes metals from non-metals.
- This line is drawn from between Boron and Aluminum to the border between Polonium and Astatine.
- only exception to this is Aluminum, which is considered to be an "other metal".
- Metalloids have properties of both metals and non-metals.

Metalloids

- metalloids, such as silicon and germanium, are semi-conductors. This means that they can carry an electrical charge under special conditions.
- This property makes metalloids useful in computers and calculators electronics.

Halogens

- The halogens are five non-metallic elements found in Group 17 of the periodic table.
- These elements are: fluorine, chlorine, bromine, iodine, and astatine.
- The term "halogen" means "salt-former" and compounds containing halogens are called "salts".
- All halogens have 7 electrons in their outer shells, usually the oxidation number is -1.

Halogens

- The halogens exist, at room temperature, in all three states of matter:
- **Solid-** Iodine, Astatine
- **Gas-** Fluorine, Chlorine
- **Liquid-** Bromine

Noble Gases

- The six noble gases are found in Group 18.
- These elements are: helium, neon, argon, krypton, xenon, and radon.
- because their oxidation number is 0,the noble gases have great difficulty forming compounds.
- All noble gases have 8 electrons in their outer shell, making them stable. (s^2p^6)

Periodic Table: Periodicity of Properties

- With increasing atomic number,
  - the electron configurations of the atoms display a periodic variation.
  - Because of this the elements show periodic variations of both physical and chemical behavior.
- The periodic law states that the physical and chemical properties of the elements are periodic functions of their atomic number.
- four physical properties of an atom: atomic radius, ionization energy, electron affinity and electronegativity.

Atomic Radius

- The size of the electron cloud increases as the principal quantum number increases.
- Therefore, as you go down a group of elements, the size of atoms in is going to increase.

Atomic Radius

- Left to right across a period, all the atoms have the same outer energy level
- For each element, the positive charge on the nucleus increases by one proton. This means that the outer electron cloud is pulled in a little closer to the nucleus. One periodic property of atoms is that they tend to decrease in size from left to right across a period of the table.

Atomic Radius

- So here is the trend for atomic radii: atomic radii increases top to bottom and right to left in the periodic table.

Ionization Energy

- energy needed to remove the most loosely held electron (usually the outermost) from an atom is known as ionization energy.
- The ionization energy tends to increase as atomic number increases in any period.
- In any group, there is a gradual decrease in ionization energy as the atomic number increases because the electrons being removed are further from the nucleus.

Ionization Energy

- However it is more difficult to remove other electrons because of greater pull from the nucleus.
- Metals typically have low ionization energy.
- Nonmetals typically have high ionization energy.

Electron Affinity

- the energy that results from an atom gaining an electron
- Metals have low electron affinities
- nonmetals have high electron affinities.
- The general trend as you go down a group is a decreasing tendency to gain electrons.
- As you go across a period there is a trend for a greater attraction for electrons.

Electronegativity

- Electronegativity is measure of the power of an atom in a chemical bond to attract electrons.
- This is measured in Pauling units.
- The electrons involved in a chemical bond are called valence or bonding electrons.
- These are found in the outermost energy levels and are usually s and p orbital electrons.
- In a group, electronegativity will decrease as you go down or remain almost the same.

Electronegativity

- Across a period there is a gradual increase in electronegativity.
- Nonmetals are generally more electronegative than metals.
- The Halogens are the most electronegative and the alkali
- alkaline earth metals are the least electronegative.

Electronegativity

- Atomic radius also plays apart.
  - Larger more easily ionized atoms will not attract electrons as strongly.
  - Fluorine is the most electronegative element on the Periodic Table.

Filling of Electron Sublevels and the Periodic Table

- The outermost electron configuration can be determined from the Periodic Table.
- The order of fill of electrons is directly related to the Periodic Table .

Filling of Electron Sublevels and the Periodic Table

- Here is how it works:

1. The elements in Groups 1 and 2 are filling the s sublevel. Examples: Li and Be are in the second period and fill the 2*s*. Na and Mg will fill the 3*s* and so it goes

Filling of Electron Sublevels and the Periodic Table

2. The elements in groups 13-18 fill the p sublevels, which can hold 6 electrons. The *p* sublevels begin to fill in the 2 period with boron (B) and is completed with Ne. In the third period Al to Ar complete the 3*p* sublevel.

Filling of Electron Sublevels and the Periodic Table

3. The transition metals in Groups 3-12 fill the d sublevels. Remember *d*'s can hold 10 electrons. We do not see *d* sublevels until the 4th period. The 4*s* is already filled. Elements 21 to 30 fill the 3*d* sublevel and 39 to 48 fill the 4*d* sublevel. Note: the principal quantum of the *d* sublevel being filled is always one less than the period number.

Filling of Electron Sublevels and the Periodic Table

4. The two sets of elements that sit at the bottom of the short Periodic Table contain 14 elements. These are called the rare earth metals and found in periods 6 and 7. The *f* sublevels are being filled and can hold 14 elements. The principal quantum number for the *f* sublevels is 2 less than the period. (Period 6 the 4*f* fills and Period 7 the 5*f* fills)

Outermost Configuration by Group

- So. Here is it is the way to figure outer most electron configuration.
- **n** is the period or principal quantum number.

Group	1	2	13	14	15	16	17	18
Outer configuration	ns^1	ns^2	ns^2np1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6

Outermost Configuration by Group

- Okay some problems. In Groups 3-12 the outer most electrons are always in **n**s^{2}. BUT the *d* orbitals are filling. SO *s* and *d* electrons can sometimes move between sublevels creating different outer shell configurations.

Ion Formation

- The elements before and after Noble gases form ions by gaining or losing electrons until they have the same electron configuration as the a noble gas
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- N^{-3} O^{-2} F^{-1} Ne Na^{+1} Mg^{+2} Al^{+3}
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- All of the above ions have the same electron configuration: $1s^2\ 2s^2\ 2p^6$

Ion Formation

- These ions and atoms are said to be *isoelectronic* meaning same electron configuration
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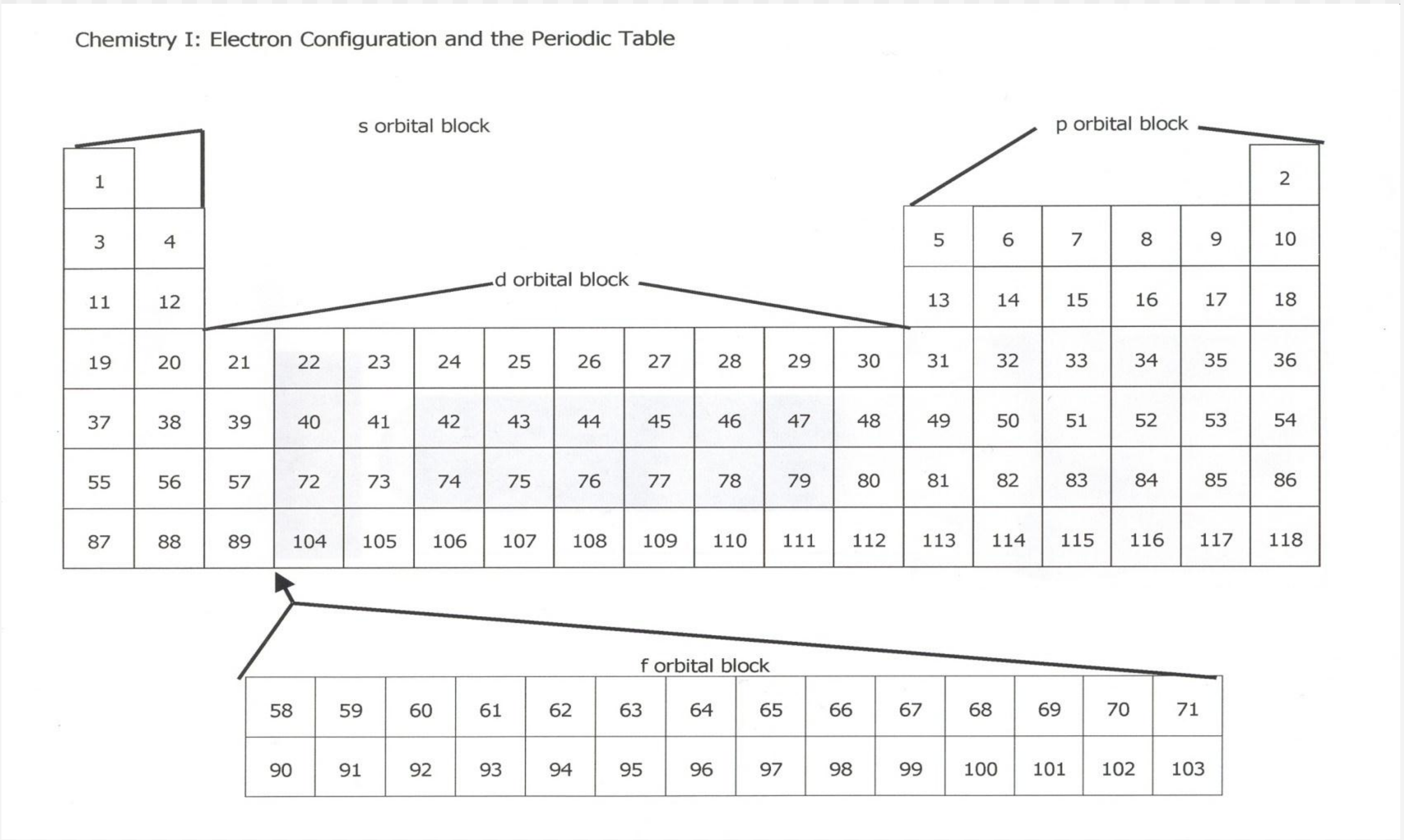
- Keep in mind atoms that
- gain electrons = a (-) charge
- lose electrons = a (+) charge

Forms of the Periodic Table

- Short form



Chemistry I: Electron Configuration and the Periodic Table

s orbital block

p orbital block

d orbital block

1																	2
3	4											5	6	7	8	9	10
11	12											13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

f orbital block

58	59	60	61	62	63	64	65	66	67	68	69	70	71
90	91	92	93	94	95	96	97	98	99	100	101	102	103

Forms of the Periodic Table

- Long Form of the Periodic Table

Chemistry I: Periodic Table & Electron Configuration / Order of Fill